THE LEHIGH QUARTERLY.

Vol. II. JUNE, 1892. No. 3.

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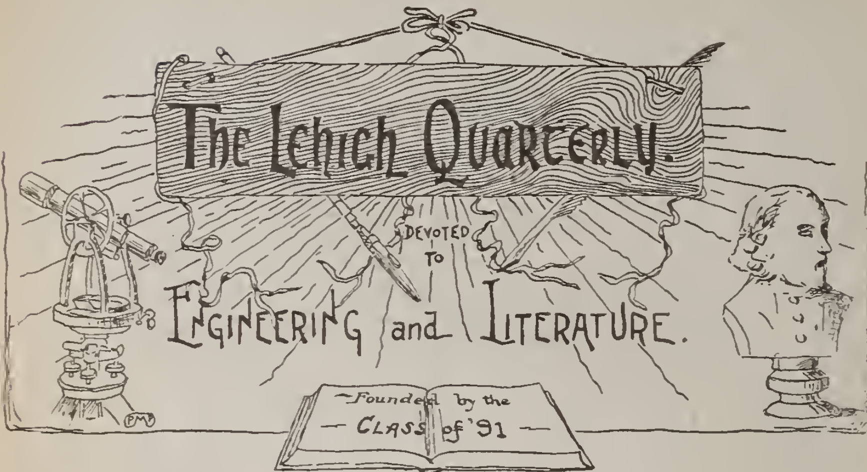
THE LEHIGH UNIVERSITY,
SOUTH BETHLEHEM, PA.



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Address all communications, inquiries, exchanges, press copies, etc., to J. Y. Bassell, Editor, The Lehigh Quarterly, South Bethlehem, Pa.

Address all subscriptions, remittances, advertising and business communications, to H. H. Davis, Business Manager, The Lehigh Quarterly, South Bethlehem, Pa.

Entered at the Post Office at South Bethlehem, Pa., and admitted for transmission through the mails as second class matter.

THE

LEHIGH QUARTERLY.

FOUNDED BY THE CLASS OF 1891.

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Vol. II. JUNE, 1892. No. 3.

THE FEDERAL PLAN OF MUNICIPAL GOVERNMENT,

As Illustrated at Cleveland, Ohio.

BY ELROY M. AVERY.

In the *Forum* for October, 1891, President Eliot tells us that "it is more instructive to discuss shortcomings close at hand than those remote, evils right under the eyes of the people than those they can hardly discern. To discuss the evils which attend municipal government is, therefore, more edifying than to consider the evils of the national and state administrations." Strangely enough, we Americans work ourselves into a quadrennial fever over affairs which are very remote from our daily lives, and give hardly a passing thought to other affairs which touch our interests at every turn. The average citizen gets his mail with tolerable regularity, no matter which party is in power; really can not tell whether his tariff "tax" is ten per cent. or fifty; and is absolutely guiltless of the faintest idea as to the relative bullion value of a gold and a silver dollar. But it does make "a great difference to him whether the city keeps good schools or bad, and clean streets or dirty; supplies him with good water or bad, and taxes him fairly or unfairly. Moreover, all critics of the working of the institutions of the United States during the last fifty years

—whether friendly or hostile, whether foreign or native—agree that municipal government has been the field in which the least efficiency for good has been exhibited, and the greatest possible evils have been developed." Few of us realize that fifty years ago there was but one city in the United States as large as Cleveland now is, or that then the entire urban population of the United States only slightly exceeded the urban population which now clusters around the shores of our great unsalted seas.

These positive evils of municipal administration sometimes become intolerable and then the people shake themselves wide awake, and with one mighty effort "smash things." Such an abrupt cataclysm put an end to the Tweed régime in New York City; another less notable subsequently struck Philadelphia. Perhaps the latest to be recorded is that which swept over Cleveland little more than a year ago. To set forth the prominent features of that change and its results, as briefly as is consistent with a clear understanding of them, is the sole object of this paper.

It is not probable that there was in Cleveland any great, corrupt, and controlling organization which defied the people and the press, but municipal affairs were notably bad and growing worse. There were occasional symptoms of official corruption, but these were sporadic rather than epidemic. Still, many down-town streets were left unpaved; paved streets were dirty; all streets were ill lighted. The city debt was growing larger every year, and the municipal income was anticipated six months at a time. The tax rate climbed to 2.83, and yet the people would not have complained if they had seen that they were getting anything for their money. The great trouble seemed to be almost universal inefficiency and no one could "put his finger on the man" who was responsible for the difficulty. City affairs were running at hap-hazard, without intelligent direction from any central source, or any coördination of the many and often diverging interests. There were a mayor and a city council of forty members elected by the people, one councilman from each ward. There were about a score of boards. Some of these were elective; others were appointive. On some of them the mayor had a seat; in others, he had neither vote nor voice. A

board controlled the schools; another, the water works; another, the work-house; another, the infirmary; another, the cemeteries. And so "board rule" went on *ad nauseum*, if not *ad libitum*, and every year or two another board was hitched on somewhere by the state legislature. In fact, our city government had several analogies to several of our old houses; built originally for a small family, and with wings, L's, and lean-to's added as wealth and children increased, the whole exhibited a motley style of architecture not pleasing to the eye, convenient for daily use, nor economical to maintain. Such was our patched and repatched charter for a town made to do duty for a great and growing city. "The mayor was only a figurehead, with little real authority, and much as he might storm and protest, he could not prevent jobbery, nor secure the adoption of needed reforms in any department. Few salaries were paid to the members of the various boards," and, as a consequence, men sometimes went into office with corrupt intentions. The people tolerated these ever-increasing abuses for years, but after a long agitation, in which the best citizens united to urge a change, the state legislature was induced to enact a bill "to provide a more efficient government for the cities of the second grade of the first class." Cleveland is the only "first-class, second-grade" city in the state, the classification being a legal device to avoid a constitutional prohibition, and to set up the fiction of general legislation for what is, in this case, special legislation for Ohio's most prosperous city. This bill was the outcome of much public discussion which had crystallized under the superintending manipulation of able lawyers. It was found to be necessary, for its passage by the legislature, to admit a few compromising amendments, each of which is a defect, and several of which have already proven sources of weakness to be remedied in the future. The new charter is commonly known as "The Federal Plan," for its most characteristic features were adapted from the national government. The legislature finally passed it by an almost unanimous vote in each house. It was to have effect from and after the municipal election to be held on the 6th of April, 1891. It did so take effect, and its first year's working is now open to our study.

The new charter makes a clear-cut distinction between execu-

tive and legislative functions—a great gain at the outset. Of the executive branch, the mayor is the central and commanding figure, and on him the people "put their finger" when almost anything goes wrong. The mayor is elected by the people and appoints the six members of his cabinet, each of whom is a "director" in charge of a department, thus: public works, law, accounts, police, fire, and charities and correction. The director of public works has charge of all street improvements, street cleaning, water-works, sewers, bridges, and parks; the director of law is corporation counsel; the director of accounts is comptroller; the director of police has the management of the police, health office, sanitary police, and weights and measures; the director of fire manages the fire department, and the director of charities and correction has charge of the work-house, infirmary, hospitals, and cemeteries. The mayor receives a salary of six thousand dollars; the director of law, five thousand; each of the other directors four thousand dollars. Experience had proved that gratuitous service is likely to be very expensive. Each member of the cabinet is supposed to give his whole time to the duties of his office, and his nomination by the mayor has to be confirmed by the city council. The city treasurer, the Police judge, the prosecuting attorney, and the clerk of the police court are chosen directly by the electors. Each director makes all appointments in his department absolutely "without the advice and consent of the council." "No officer or employee of any department shall attend, or be a member of, or a delegate to any political convention at which municipal officers are to be nominated," and violation of this provision of the law must be met by removal or discharge. A director may remove or suspend any employee in his department by written order, a copy thereof to be filed with the mayor, "provided the same shall not be done for political reasons," and, further, that any member of the police force or of the fire force may appeal from such order to a tribunal consisting of the mayor, the director of law, and the president of the city council. This throws the shelter of civil service reform over policemen and firemen, and, as experience has shown, still leaves it easy to weed out inefficient or unworthy employees.

The mayor and the six directors constitute the "board of

control," in which is vested all the powers previously held by the board of improvements, the commissioners of sewers, and the board of revision. This body must meet at least twice each week and constitutes one of the most important agents of of the city.

The legislative functions of the city government are vested in a council of twenty members. For this purpose, the forty wards are divided into ten districts, from each of which, each year, a member is elected to serve two years. Each member of the council receives five dollars for "each regular weekly meeting" that he attends. For the last year, the attendance at such meetings has been remarkably good. The council elects its own president and vice-president, a city clerk, a sergeant-at-arms, and a page; the clerk appoints his own assistants, subject to confirmation by the council. Other than these "the council shall exercise no power of election or appointment to any office." Experience has already proved that it was wise to exempt the councilmen from all besieging attentions of seekers for positions which formerly were at the disposal of the council. They go now to the directors, and the directors are well paid for giving them proper attention. The council may, by ordinance, create subordinate positions, and determine the corresponding duties and pay; having done that, it has exhausted its powers in the matter. The council, or any of its committees authorized by it to do so, may compel the attendance of witnesses and the production of books and other documents in any case of inquiry and investigation. In case of refusal, the council may commit to prison for contempt. One of the first acts of the "Federal Plan" council was to exercise this power to compel the attendance of witnesses and the production of books in an investigation of the affairs of the local gas companies, which investigation resulted in the passage of an ordinance reducing the price of gas from a dollar per thousand cubic feet to sixty cents.

No money may be expended, or contract approved, or franchise granted, or right created, until after at least a week has intervened between the introduction of the ordinance or resolution therefor and the action thereon. Excepting for improvements recommended by the board of control, all such ordinances and reso-

lutions must go to the mayor for approval or veto. To pass such a measure over the mayor's veto requires fourteen votes. In the last year there were seven such vetoes, of which only one was overridden.

The mayor and directors have seats in the council with the right to speak, but not to vote. The council is given power to compel them to attend its meetings, and they are habitually present.

Of course, there are many other provisions in the act, but the foregoing is sufficient to give a general idea of the nature of the new organization. It remains only to state what, in its first year, the "Federal Plan" has done for Cleveland. An adequate understanding of the value of an agency employed involves a corresponding understanding of the work to be done. To reform a hamlet is one thing, to reform a great manufacturing city is quite another. It therefore becomes imperative to show something of what Cleveland is.

Few persons have a fair idea of Cleveland's magnitude and importance. The present writer has often been put to the trouble of hunting up a census report or table to convince some generally well-informed friend that Cleveland is not smaller than Buffalo, New Orleans, Pittsburg, or Detroit. The growth of Cleveland has been so phenomenal and yet accompanied by so little bluster that it is difficult to realize that a settlement which had only four inhabitants in 1796 and 1075 in 1830 had 92,825 in 1870, 160,141 in 1880, and 261,353 in 1890. The figures in each of these nineteenth century dates are taken from the returns of the United States censuses.

Even these statistics of population give but a poor idea of what has taken place in Cleveland as an industrial center. A recent article in *Scribner's Magazine* says that "the history of marine architecture does not furnish another instance of so rapid and and complete a revolution in the material and structure of floating equipment as has taken place on the great lakes since 1886." During the four years 1886–90 the tonnage of the great lakes was nearly doubled, and the number of steamers of more than fifteen hundred net register tons increased from twenty-one to one hundred and ten. In a recent address by the Hon. Robert P.

Porter, superintendent of the eleventh United States census, he says: "Notwithstanding that Cleveland is so far removed from the seaboard coasts, she occupies the proud position of standing first on the list of ship-building cities in the United States, and second only to the Clyde, the most extensive ship-building location in the world." For the two years 1889–90 the tonnage at the principal ship-building cities of the United States is given as follows:

Cleveland, ...	71,322 tons.
Philadelphia, . . .	53,811 "
Bath, Me., ...	49,838 "

The mileage of the railways centering in Cleveland (not merely tributary, for that would largely increase the report) aggregates 5237 miles more than that of Sweden, and nearly twice that of Belgium. In 1890 they carried 37,829,711 tons of freight, gave employment to 37,684 men, and brought in gross receipts to the amount of $56,087,349.

In the decade 1880–90 the number of manufacturing establishments in Cleveland increased from 1055 to 2065; the capital invested from $19,430,989 to $53,975,346; the number of adults employed from 20,304 to 50,359, while, even better than this, the number of children employed fell from 1420 to 990. The total of wages paid increased from $8,502,935 to $30,428,635, and the value of products from $48,604,950 to $98,926,241. It is to be noted with satisfaction that the increase in wages paid is greater than the increase in number of persons employed.

A comparison of the cost of material used and the value of the product will give what is called the enhanced value due to manufacture, and, in comparisons of this kind, this enhanced value always should be considered. For example, the enhanced value of a slaughtering and packing establishment is only ten per cent. of the material used, while in ship-building it amounts to more than one hundred per cent. In 1880 this enhanced value for Cleveland's industries was $16,974,313, while in 1890 it was $41,605,168. The product was doubled, the enhaced value was nearly trebled,—a very satisfactory gauge of industrial enterprise.

Surely, Superintendent Porter had ample justification for using

these words of congratulation to his Cleveland audience: "In ten years you have doubled the number of your establishments and the value of the products; you have nearly trebled the capital invested in manufactures, multiplied the total number employed two and a half times, and you are paying out annually in wages more than three times as much as you did in 1880. If you are not proud and happy over this statement you ought to be. Remember that our (census) figures may prove up a little in excess of the above, but they can not be less. On file yonder in Washington we have carefully put away a schedule sworn to by the special agent as a true and faithful statement of the condition of every one of 2065 manufacturing establishments of this city. These statements are cold, clear, official statements of facts, and not warmly colored, exaggerated offerings to the altar of local pride. They show exactly what you have done the last ten years, and it affords me great pleasure to congratulate you on the tremendous showing, for such it is. It places Cleveland in the front rank as one of the great manufacturing cities of the Union."

In a spirit of exultation over their final release from their long-endured, inefficient, and extravagant board system of city government, the Hon. William G. Rose was a second time elected mayor on the 6th of April, 1891. He was inaugurated on the 20th of April, and at once appointed the heads of departments as follows: Director of law, Gen. Edw. S. Meyer; director of public works, R. R. Herrick, another ex-mayor; director of police, Col. J. W. Gibbons; director of fire, Col. Louis Black; director of accounts, F. C. Bangs, and director of charities and correction, David Morison. During the year Director Black resigned, and "Commodore" George W. Gardner, another ex-mayor, was appointed in his place. On the whole, the executive department was well organized, and commanded the confidence of the citizens. The case was very fairly stated in a newspaper article written by the mayor's secretary last October, in which he said: "With one or possibly two exceptions, the board of control is composed of men who are in every way well qualified for their positions, and even the exceptions are not extremely objectionable." The improvements to be recorded are due as much to the character of the administrators as to the system of govern-

ment itself. Constitution makers and legislators "do all they can to support the weakness of human virtues when subjected to the temptations of power and place. But virtue can not be dispensed with in this world. No system of checks and balances can be made so perfect but that much must be left, after all, to the honor of governing persons."

Most of the statements printed in the New York *Post* last October held true to the end of the year. That the city government was a great improvement on its predecessors, no unprejudiced observer here can doubt. Never, in recent years at least, had there been such thorough system and order in all departments, and such persistent and keen watchfulness of the public interests. Street contractors were brought to time as never before. Paving and sewer contracts were pushed to completion rapidly and the work done much better than the average of former years, and contractors were compelled to clean up the débris after them. The streets were never so well cleaned before and, in general, public works were carried on in the people's interests and not solely at the convenience and for the profit of contractors. The most marked feature of the year was a vigorous struggle with corporations enjoying valuable franchises from the people, the gas and the street railway companies. Efforts to protect the rights of the public against the corporation greed of those who had grown rich on their bounty and to force obedience to the proper mandates of the city government were resisted by all the devices known to the law's delay. Injunctions dissolved were followed by appeals and fresh injunctions, until now the most important cases are in the United States courts, where, thanks to the skill and the brave and unflagging efforts of the city's director of law, a favorable issue is expected in the near future.

On the 18th of April, 1892, the mayor submitted to the council his first annual report and from it, as the best official source of information at command, are culled some of the leading items as to what has been accomplished.

In 1891 the water-works service-pipes were extended more than nineteen miles, more than three thousand new connections were made, and more than eleven and a half billions of good

lake water was pumped for the use of city and citizens. More than thirteen and a half miles of street paving was laid, in addition to what was done by private parties, an increase over the amount done in any previous year. Most of this was of the best block stone; the cost was nearly six hundred thousand dollars. At the close of the season only two contracts were unfinished and those for paving streets of minor importance. Nearly twenty-two miles of sewer were built (an increase of thirty-three per cent. over the record of the previous year) at a cost of nearly half a million dollars. Forty-eight streets were graded or curbed, or both, and ninety new streets and alleys opened and dedicated to public use. From 1881 to 1890 the annual operating expenses of the city government had increased from $811,651 to $1,653,027, more than double. The average annual increase was $84,075. This natural tendency of the cost of government to increase with the growth in wealth and population was overcome, and the year showed a decrease of $81,924.

It had been a long time the custom to carry over to each new fiscal year unpaid bills, and to make advance drafts on the taxes for the following year. The "Federal Plan" puts an end to this pernicious practice, and each year's expenses must be paid from that year's revenue. Thus the new government found itself between two grindstones, an accumulation of unpaid bills, and a strictly limited income which had been largely spent by its predecessor. The total of unpaid bills on December 31, 1890, was $101,416. By December 31, 1891, the new administration had reduced this by $47,623. The reduction was made with funds charged in the operating expenses for 1891, and should, therefore, be added to the already mentioned saving of $81,924, making thus a total annual saving of $129,547.

When the increase of efficiency is contrasted with this large saving, the justification of the "Federal Plan" seems to be ample. But it must still be added that no advance drafts were made in 1891 on the revenues of 1892, and that between New Year Day and the middle of April, 1892, the balance of unpaid bills inherited had been wiped out. The above figures do not include more than a million dollars paid during 1891 as special improvement taxes, in which the city simply loaned its credit to its tax-

payers, so that the money needed might be secured at a low rate of interest. An illustration of the reinvigorated credit of the city is found in the fact that in April, 1892, an extension of water works four and a half per cent. bonds to the amount of four hundred thousand dollars was made and a premium of about twenty-four thousand dollars secured. These financial results are satisfactory to our citizens, but the good service of the "Federal Plan" can not be wholly measured in dollars and cents.

In the mean time the success of the new government emphasized the unsatisfactory condition of school affairs, where corruption was more commonly believed to exist than had ever been the case in any other branch of municipal affairs. An agitation for reform, earnest, persistent, and well directed, resulted, last March, in the enactment by the Ohio legislature of a new school law for Cleveland. The old board of twenty members, elected one from each of twenty districts, was abolished and for its place a new school council of seven members, elected by the city at large, was provided. An executive head of the school system (corresponding to the mayor) was provided with the title of school director. "School dictator" the friends of the old régime call him. He is elected by the city at large, and his salary is fixed at five thousand dollars. The school council is the legislative body, and its members serve without pay—a weak feature of the law. This council has the power to provide for the appointment of (but not to appoint) all necessary teachers and employees, prescribe their duties and fix their compensation. The school director has all the power not vested in the school council. He appoints and may remove the superintendent, and the superintendent appoints and may remove the assistants and teachers at discretion. The director appoints all janitors, makes all contracts for which money has been appropriated by the council, and has a veto on any resolution of the council involving an expenditure of money, or for the adoption of any text-book. To override a veto of the school director requires the votes of six of the seven members of the school council. The city director of accounts is the auditor of the school council, the only cord binding the school headquarters to the city hall.

At the election in April, 1892, Mr. H. Q. Sargent, a well known business man, was elected Cleveland's first school director.

Last October the correspondent above quoted said:

"It remains to be seen whether or not it is merely a case of a new broom sweeping clean, and how long the present charter will remain undisturbed by legislative tinkerers. The old gangs are very bitter against the present government, and will certainly leave no stone unturned to supplant it by one subservient to their interests at the first opportunity."

On this the New York editor made this comment:

"We have no hesitation in predicting the success of the 'old gangs.' We have had a very similar experience here. In a fit of reformatory zeal, after having tried many other things, we got absolute power of appointment given to the mayor in 1884, on the theory that this would make the voters very careful in the selection of our chief magistrate. Accordingly, the two following elections gave us excellent mayors in the persons of Mr. Grace and Mr. Hewitt. But very soon the old disease showed itself with renewed virulence. Both parties came to the conclusion that they really must make the mayoral election a Presidential election; that it would never do to vote for the mayor with a single eye to the interests of the city, and that we must consider mainly the effect of our choice of mayor on the Presidential election. Nothing could suit 'the old gangs' better than this notion. They fostered it carefully, and in 1888 they succeeded in electing their own man, and the beautiful plan of 'concentrated responsibility' speedily went to the dogs."

At the municipal election in 1892 there was no mayor to be elected, but the terms of half the members of the city council expired. The franchise-enjoying corporations took an active hand in the election of councilmen, but it is now pretty sure that they failed in their efforts. Time alone will tell.

That the "Federal Plan" is a success so far is generally conceded. The daily local papers teem with such editorial comments as "One more victory for the Federal Plan," or "Hardly a day goes by but the public has cause to congratulate itself upon the business-like way in which the city affairs are managed," or "The Federal Plan saved $129,000 the first year. Let the Federal

Plan stay," or "There is honor now in the council, a fact that encourages the hope that many good men will be willing to run. Things are not as they used to be."

In a recent issue the Cleveland *Leader* declared that "The success of the Federal Plan is due in the main to the substitution of strict business methods for the often corrupt jobbery that characterized the conduct of municipal affairs under the old board system." Newspaper utterances like these, of course, have a deep significance. That there may be a like feeling of content at the end of another year is the earnest hope of the present writer and of all our good citizens.

All in all, the present attitude of Cleveland residents as to the affairs discussed in this paper are fairly set forth in the following editorial article which appeared (April 20, 1892) in the Cleveland *Leader*:

"After one year's trial the new plan of managing the business of the public schools will show results, we doubt not, which will be quite as satisfactory to the taxpayers of Cleveland and to all good citizens as the splendid record of economy and efficient administration which has been made by the municipal government. The reforms brought about in the management of the affairs of this city have been well worth all the trouble and effort which they cost, merely as a matter of dollars and cents, and who can estimate the value of the decency and honesty which everybody knows have characterized the management of the public's business? It will not do, henceforth, for any Clevelander to say that the better elements of our city's population are powerless in municipal affairs or unable to secure good government if they will make an earnest effort to that end."

NOTES ON BOILER WATERS AND ON THE INCRUSTATIONS RESULTING FROM THEIR USE.

(CONCLUDED.)

Ammonium chloride is sometimes used in boilers, and is very effective in removing lime and magnesia salts, even after they have been deposited as a hard crust. It decomposes carbonates of lime and magnesia with the formation of ammonium carbon-

ate, and calcium and magnesium chlorides. The former decomposes at the temperature of the boiler, and the latter compounds, being very soluble, remain in solution. Ammonium chloride is a very efficient boiler compound, but the objections to its use are the strong ammoniacal odor of the escaping steam, the liability of priming, and its expensiveness.

Dr. Rogers proposes the introduction into the boiler of a sufficient quantity of sodium oxalate to cause the immediate decomposition of the scale-forming salts as they enter the boiler, converting them into insoluble oxalates, which precipitate as a mushy sediment with no tendency to form hard scale. The same precautions with the use of soda are then observed to keep the boiler free from the accumulation of sludge.

There is another method of preventing scale formation by the use of tannate of soda which is kept constantly present in the boiler in solution. It decomposes the carbonates of lime and magnesia, converting them into light amorphous forms which do not settle, but are kept in suspension by the boiling currents until they gradually find their way into some of the receivers with which the boilers are provided, where they settle as a light, mushy mass, which may easily be blown out from time to time.

The sodium carbonate formed in the reaction is retained in solution, becoming sodium acid carbonate by appropriating the free carbonic acid from the water. This decomposes calcium sulphate with the evolution of carbon dioxide, and the formation of sodium sulphate and calcium carbonate. The former goes into solution, and the latter is attacked by fresh portions of tannate of soda. The same reactions take place with the tannate of soda and the scale already formed, with like results, but more slowly, some weeks generally being required in practice to remove the deposit if it exists in any considerable quantity. The constant presence of alkali protects the iron from all corrosive action, either of carbonic or tannic acids. The method is practicable for all boilers.

Metallic zinc has been largely used in boilers, both to prevent corrosion and the formation of incrustation. The results attendant upon its use differ widely. Where corrosion is caused by the presence of an acid in the water the action is simple and the results satisfactory. But free acid, carbon dioxide, oxygen, etc.,

are not the only substances which occasion corrosion. There are other and more important causes, an investigation of which has not only thrown a great deal of light on the true changes which take place within a boiler, but has developed scientific reasons why zinc should be of service.

From 1874 to 1880 the English Admiralty had a committee appointed to investigate the action of zinc within marine engine boilers. The results of the committee's work may be summarized as follows:

With regard to a prevailing belief that the presence of copper in a boiler was a source of injury, they state: (1) The quantity of copper carried into a boiler is extremely small; and (2) no injurious effects of importance can be produced by it.

(3) The use of mineral oils only is recommended for lubrication.

(4) Moist air and water containing air are powerful corrosive agents. They recommend increased density in the water, especially in boilers fed from surface condensers, and that the boiler should be emptied as seldom as possible.

The committee made numerous experiments with the use of zinc plates, most of which were in the methods of fastening the same in or to the boiler. The plates were hung over the staybolts, strapped or bolted to the sides of the boiler, but the inevitable result was that, after a week or so of service, the plates became inactive and useless. Even an excessive number of plates failed to afford protection for any considerable length of time.

Mr. Hannay, of Glasgow, was at work on this subject at the same time as the Admiralty Committee, but independently of them. His researches as published in the *Scientific American Supplement*, No. 444, are very interesting, as they represent a great portion of all the successful scientific labor that has been spent upon the solution of boiler troubles. The boilers upon which Mr. Hannay was at work were subjected to continual corrosion. The common belief was that such corrosion was mainly due to oxygen and carbon dioxide dissolved in the water. By experimenting with various chemicals he succeeded in removing every trace of these substances from within the boiler, but the

corrosion still continued. The conclusion was that, though free oxygen and carbon dioxide undoubtedly promoted corrosion, they were not the chief causes.

It was next thought that certain parts of the boiler which are more highly heated might have their surfaces so altered as to become electro-negative to the colder parts. This seemed probable, as corrosion so often took place along certain well defined lines, as, for instance, along the fire-box. From an observance of these facts the theory was advanced that thermo-electric currents were set up between the colder and hotter parts of the boiler, and that the colder parts, forming the positive pole, corroded by the natural law of galvanic action. A boiler was then constructed which could be readily heated in sections. Two iron plates were fixed in the boiler, one near the top and the other near the bottom, and both were connected with a galvanometer, so that a current passing from one plate to another could be detected and measured. The boiler was heated alternately more strongly at the top and at the bottom, with the constant result that whenever the temperature of one plate rose above the other the cooler plate became positive and wasted away. It is obviously impossible to construct a boiler so that all of its parts shall be heated uniformly. The difficulty must be overcome in another way.

It appeared, therefore, that the only method of preventing this corrosion was by making the iron all negative by a current stronger than that set up in the iron itself by the difference in temperature. The current was estimated and found to be very small; a weak battery was fitted up, and the positive electrode, or wire, passed into the water of the boiler, the negative electrode being soldered to the outside. After six months' trial it was found that the corrosion had entirely ceased.

These facts are then made clear: (1) Natural electric currents, so to speak, caused corrosion, and (2) a stronger artificial current could be made to overcome it.

The theory of zinc in contact with iron, preventing corrosion, is this: Take two pieces of metal, one zinc and the other iron, and immerse them in dilute acid, and both are attacked. Connect them with a wire, and they at once become a galvanic

couple. The zinc, being more electro-positive, crumbles away and the iron is not attacked. This will remain true as long as the galvanic current is complete. The use of zinc is then scientific and correct. The next inquiry was to find the cause of failure in zinc as ordinarily employed.

After thorough and complete experimentation with zinc slabs it was found impossible to prevent corrosion from destroying the galvanic contact of the metals. Water would find its way into the joints, occasioning a thin film of zinc oxide and thus spoiling the metallic contact. This usually happens in from five to thirteen days, even with extraordinary care. After many trials the conclusion was reached that no mechanical attachment of the zinc, however perfect it may be, will suffice to secure a continued maintenance of the current. To meet the various defects in the use of zinc plates, a ball of zinc was designed, having a copper electrode through the center, the copper being so combined and alloyed with the zinc at the junction of the two metals as to form brass, and thus no corrosion could form between them to stop the galvanic current. The ball of zinc is called an "electrogen." It is fitted in any convenient part of the boiler by a simple device, and a wire from each end of the copper conductor firmly soldered to the iron. It was ascertained by further experiment that a very small surface of zinc was sufficient to afford protection for a radius of twenty-five feet from the point of contact, and the spherical form of zinc was adopted, as it would maintain perfect protection with a minimum of waste. Mr. Hannay made a departure here from the prevalent belief that efficiency was, in a measure, dependent on the amount of zinc surface exposed.

But its greatest advantage is not in the prevention of corrosion, but that it does not allow scale to form in a boiler, at any time, to a much greater thickness than that of an eggshell or a coat of paint. The zinc ball, with its perfect contact, generates a current of greater intensity than zinc plates mechanically filled. The consequence is that a portion of the water is slowly decomposed, and the hydrogen that is evolved at the negative pole, all over the surface of the iron and underneath the scale, forces off the scale in thin flakes by mechanical action as soon as it becomes

thick enough to be impervious to hydrogen. The flakes of scale are of such a nature as to be easily removed by the application of the same directions as are observed in the use of sodium carbonate and other chemical precipitants.

The results obtained by the use of the "electrogen" with sea water are very satisfactory, and the author claims that it has also solved the problem of fresh water incrustation and corrosion. To make it sufficiently active in fresh water the homœopathic principle of *similia similibus curantur* is applied. Mr. Hannay adds to the fresh water about the same amount of salt as is contained in sea water. The efficiency of his appliance is then established.

That his method of attachment is a great improvement over any previous method of using zinc is undeniable. Especially is this the case with marine engine boilers. But where there are so many boiler compounds of established merit from which to select the question of adding a considerable amount of salt to a water, in order to secure the advantages of the zinc ball "electrogen," would certainly not meet with the approval of most practical men who have had experience in the care of steam boilers.

Tri-sodium phosphate is another compound used quite commonly and satisfactorily, especially with many of the waters of this locality. Its chemical action is simple. The dissolved lime and magnesia salts are converted into insoluble phosphates, which precipitate in a light, flocculent form, easily removable from the boiler. It exerts no injurious action on the tubes or plates. It will also neutralize all acidity that may exist in the water. In the use of this compound the very best results are obtained when two settling tanks are employed, each having a capacity of one day's water supply for the boiler. The boilers are then fed with the purified water, which is drawn off from a spigot near the bottom of each tank. When empty, the tank is washed out, filled with water and treated as usual. It requires about five hours for the mineral matter to settle. By this process the boiler is run on moderately pure water, thus rendering frequent blowing off and washing out unnecessary. The process is of great advantage in connection with stationary boilers, but, as has been previously mentioned, the large amount of water consumed by loco-

motive boilers would necessitate the erection of immense tanks with the resulting expense and inconvenience. For railroad use it is advisable to treat the water within the boiler. As a preliminary guide to the amount of compound necessary, the Keystone Chemical Company, in their pamphlet advertising the use of tri-sodium phosphate, proceed substantially as follows:

"Take one quart of water, and add to it one grain of tri-sodium phosphate, accurately weighed out. Boil and filter, and repeat the process with the filtered water until no further precipitation occurs. The water is then free from scale-forming ingredients, and the number of grains used will represent the number of pounds of compound necessary to purify 2000 gallons of water. This is enough to run a 50-horse power engine for ten hours. One-quarter of the test quantity will, in most cases, keep the boiler perfectly clean."

While the above is not put forth as a model example of laboratory work which should be done in connection with boiler waters, the process is simple and can readily be performed without much knowledge of chemical manipulations. The results merely serve as a guide. No matter how thorough the previous investigation of the nature and composition of the water may have been, the boiler should be examined after every two or three weeks' use with the compound. If the scale is removed, the amount of tri-sodium phosphate may safely be lessened. If the incrustation is not being entirely prevented, an increase is necessary.

Fruit, cider, vinegar, cane juice, and a variety of other substances, containing acetic acid, have been recommended for use in overcoming incrustation. They decompose the carbonates, converting them into soluble acetates, but leave calcium sulphate, the worst of all scale-forming ingredients, unaffected. In addition to this, the iron of the boiler is as much attacked as the precipitate, so that their use is not to be recommended. They might prove useful, in some rare cases, when the waters are abnormally high in the ratio of calcium carbonate to the other scale-forming substances. Nut galls, catechu, oak, hemlock and tan barks, tormentillo root, mahogany, logwood, etc., also serve to prevent incrustation. The active principle is their tannic

acid. Basic tannate of lime is formed, which separates as a loose, unadhesive powder. These bodies are evidently similar in their action to the foregoing class, inasmuch as they only attack the carbonates, leaving the sulphates unchanged and as harmful as ever. They also corrode the boiler metal, but the action is not as noticeable as with the acetic compounds. In practice, however, they are much more efficient than would be theoretically supposed. As an example, it may be stated that there are but few compounds that give more satisfactory results than a strong extract of logwood. The great advantage claimed for all the members of this class is that they are not apt to cause priming.

There is another class of bodies, which, though not strictly chemical agents, are somewhat similar in their action to the previous classes and prevent scale formation. The simplest of these substances are those of starchy origin, such as Indian corn, potatoes, linseed oil cake, and also various gums, dextrin, Irish moss, slippery elm, marshmallow root, glue, etc. They prevent scale from forming by causing the precipitated particles to become enveloped with gelatinous matter and preventing, more or less completely, the hardening and settling of the deposits. The objection to their use is that they are very uncertain in their action, and that they invariably cause priming, so much so, in fact, that it is often impossible to determine the amount of water in the boiler from the gauge reading.

Within recent years petroleum oils have been constantly gaining favor for use in steam boilers. The real chemical action of these oils on the incrustation is not well understood. That their use does, however, cause both the removal of the old incrustation and the prevention of the formation of new, can not be gainsaid. In using petroleum oils it is absolutely necessary to start with small quantities, which, for a boiler of 100-horse power and with average water, should not be much over two quarts per week. Many cases are cited where excessive quantities of oil have been introduced into the boiler with the object of causing the speedy removal of the old scale, and the result has been that after a few days' use the tubes began to leak and the crown sheet to bulge. On examination it was found that the petroleum had combined with the scale on the crown sheet and formed a mass of the con-

sistency of soup, which prevented the water from reaching the plates. This difficulty should not arise if the petroleum be introduced in small quantities.

Some authorities recommend the use of the lighter petroleum products, on the ground that these oils do not have as much "body" as crude oil and are less liable of combining with the scale to form a greasy paste, thus preventing the water from reaching the plates and subjecting the boiler to danger from overheating. Mr. L. F. Lyne, of New York City, is inclined to favor the use of the lighter petroleum oils. In two papers read before the American Society of Mechanical Engineers he gives some interesting data in support of his belief. One of the arguments against the use of any form of oil in a boiler is that the oil would not touch the incrustation, but simply float on top of the water. Mr. Lyne has shown that this opinion is wrong by the following experiments: A piece of hard scale was put in a glass tube one inch in diameter with a tablespoonful of water, the surface of which was covered with a film of kerosene oil. Heat was then applied with a bunsen burner. When ebullition began the kerosene separated into globules, and followed the sides of the tube to the bottom, rising again through the center to the surface. This action continued as long as the tube was heated and proved that kerosene oil would not remain on the surface of the water in a boiler. This view was afterwards verified beyond doubt by drawing water from near the bottom of various boilers in which kerosene had been used to remove incrustation, when it was found to be thoroughly impregnated with the oil.

In 1882 Wm. Major, engineer of the Danish Royal Navy, published a paper on the priming of steam boilers, the contents of which are so intimately connected with the use of the petroleum oils that a short review of his results will be appended. The author claims that priming is caused by the friction on the outer surfaces of the steam globules as they pass up through the overlying body of water, and the amount of such friction is always in the ratio of the velocity at which they pass through the body of water, and also depending on the state of the water as regards its purity.

The results of the author's experiments were similar to those of Mr. Lyne, and show that when oil is added to a boiler it immediately diffuses itself throughout the whole contents. If the above is a true statement of the cause of priming, it is consistent to infer that, by lubricating the globules of steam on their passage through the water, the priming could be diminished. To effect such lubrication, he recommends the use of the lighter petroleum oils, which, in addition to overcoming the friction and diminishing the priming, will also check and remove all species of incrustation.

The following advantages are said to be attendant upon the use of the petroleum oils:

(1) Prevention of priming.

(2) Prevention of injurious effects on the cylinders by water passing over with the steam.

(3) A reduction in the quantity of feed water and fuel, due to the fact that the steam is drier.

(4) Augmented boiler steam power, by the total absence of incrustation or corrosion.

(5) Prevention of corrosion.

(6) Its instantaneous action in any disturbance of the water in the boiler.

(7) Increased durability of both boiler and engines.

III. MECHANICAL METHODS.—The readiest and therefore the most frequently used of the mechanical means for the prevention and removal of incrustation is "blowing off," or blowing out the boiler. The arrangement for blowing off usually consists of one or two internal pipes extending from end to end along the bottom and in connection with the blow-out tap. These pipes are usually carried 1½ inches clear of the plates, and are perforated on their under side. This arrangement is very efficient when the impurities settle readily. If the incrusting ingredients are calcium and magnesium carbonates, and their precipitation is allowed to go on without the introduction of boiler compounds, the only method to prevent scale formation is to blow off to a slight extent every hour, and then thoroughly after the boiler has remained at rest for some time and the deposit has settled. The full

benefit of blowing off is realized when the impurities of the water are precipitated in a fine granular condition by the action of some chemical compound. The objection to it is that it occasions a considerable waste of steam.

If the water contains a great deal of suspended matter, it may often be rendered fit for boiler use by filtration. This can best be done by forcing the water upward through a layer of pebbles, bones, and other suitable substances.

The simplest of the mechanical methods is resource to the manual labor of picking, scraping, and cleansing. The boiler is more or less injured by this treatment, and the process is expensive, especially from loss of time.

Various mechanical contrivances have been introduced, intending to intercept the precipitated saline matter on the passage of the water through the heating apparatus, where it is heated almost to boiling by the exhaust steam. A portion of the carbonates and sulphates precipitate from the hot water and subside more or less completely on shelves, straw, or other obstructions. The bulk of the mineral matter is in solution and passes on into the boiler. The scale forms more slowly, but just as surely. It is evident that no purely mechanical device can ever be wholly successful.

A practice much resorted to by engineers is to crack the larger incrustation by a sudden expansion or contraction of the boiler shell. The contraction is effected by blowing off the boiler with the steam up and then suddenly letting into it a volume of cold water, or by opening wide the furnace doors, chimney damper, and entrance to the flues as soon as the fires are drawn. The expansion is effected by cooling the boiler and allowing it to stand until quite cold. Steam as hot as is obtainable is then let into the closed up boiler. Neither of these methods can be too strongly condemned.

Dr. Charles F. Chandler, after a thorough and complete investigation of locomotive boiler waters and incrustation, gave the following advice:

(1) The use of the purest waters wherever possible.

(2) Frequent use of the blow-off cock.

(3) That the boilers should never be emptied while there is fire enough to harden the deposit.

(4) Experimentation on the efficiency of zinc, lime water, soda, ammonium chloride, and some substance containing tannic acid.

One fact to be borne in mind, in connection with the boiler waters and the prevention of incrustation and corrosion, is that the only safe way of avoiding trouble is to entirely disregard the use of any haphazard preparation, until some knowledge of the nature of the evil has been ascertained. In every case have a careful analysis of the boiler water made, and if any considerable incrustation has formed have that analyzed also. The information thus obtained will usually enable one to select the proper preventative at once, and beyond doubt. If not, a very little careful experimenting will determine the proper course. There is no operation connected with the handling of steam power but which requires intelligence, and the indiscriminate use of boiler compounds without intelligent forethought is worthy of severe condemnation.

ALBAN EAVENSON, '91.

A DETERMINATION OF LONGITUDE BY MOON CULMINATIONS.

If, after carefully determining the sidereal time at any place, we observe the time of transit of the moon over the meridian at that place, the result of our observation will be a determination of the moon's right ascension at culmination.

This follows at once from the definitions of right ascension, meridian, and sidereal time.

By computing, with the aid of the ephemeris, the Greenwich sidereal time at which the moon had this right ascension, we obtain the Greenwich sidereal time corresponding to the local sidereal time of the moon's transit.

The difference between the two times will then be the difference in longitude,—in other words, the longitude of our instrument east or west from Greenwich.

Having, then, set up our transit instrument in the meridian, we observe the times of transit of the moon's bright limb over the threads of the telescope. In case it is very near the time of full moon, the dark limb may be observed also, after which both times of transit will be reduced to the time of transit of the moon's centre. This is done by applying to the bright limb a correction equal to the sidereal time of the semi-diameter passing the meridian, and to the dark one a quite similar correction, but that here the sidereal time occupied by the defective half of the moon passing the meridian must be used instead.

If S be the geocentric semi-diameter of the moon,
S_1 the distance from the dark limb to the centre,
d the moons right ascension (approximate),
δ_s and d_s the sun's declination and ascension respectively, and x the angle which a line from the sun to the moon forms with the plane of the meridian,
we will have *

$$sin\ x = cos\ \delta_s\ sin\ (d_s - d) \qquad (1)$$

$$S_1 = S\ cos\ x \qquad (2)$$

S is given in the ephemeris for each day.

The observed times of transit are liable to two sources of error,

(1) Errors of the transit instrument.

(2) Errors of the clock.

The former will be (a) errors of collimation, due to the line of collimation not being perpendicular to the rotation axis of the instrument, (b) error of azimuth, and (c) errors of level, due to one end of the rotation axis being higher than the other, and also due to the pivots of the rotation axis being of unequal size.

If τ be the east hour-angle of a star when seen on the middle thread,
c be the error of collimation, + when the star reaches the thread too soon,
$(90° - a)$ be the azimuth of the point where the west end of the rotation axis pierces the celestial sphere, and
b the altitude of the same point,

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* The derivation of all the formulas to be used will be found in Doolittle's Practical Astronomy, third edition. In most cases it is too long to be given.

we shall have, when observing a star of declination δ

$$\tau = a \sin (\phi - \delta) \sec \delta + b \cos (\phi - \delta) \sec \delta + c \sec \delta \quad (3)$$

where ϕ is the latitude of the place of observation.

The errors of the clock will be those of rate, and the error of time. Letting ΔR be the clock correction to the latter at the time T_0, T_1 be the time indicated by the clock as the instant of a star's transit, and δR the hourly rate, then the true right ascension of any observed star will be

$$\alpha = T_1 + \Delta R + \delta R (T_1 - T_0) + a \sin (\phi - \delta) \sec \delta + b \cos (\phi - \delta) \sec \delta$$
$$+ [c \sec \delta - .021 \sec \delta \cos \phi] \quad (4)$$

The expression $-.021 \sec \delta \cos \phi$ is the correction for diurnal aberration, at upper culmination.

b is determined by the formulæ

$$\beta = \frac{d}{2} (W - E), \quad (5)$$

$$b = \beta \pm p, \quad (6)$$

where W and E are the respective means of the west and east readings of the level placed upon the rotation axis, d the value of one division of the level, and p a small correction for inequality of pivots.

We then have one equation between the four unknown quantities ΔR, δR, a and c. By observing four stars whose right ascensions are known we obtain four such equations, whose solution gives the corrections desired. In practice a much larger number are of course observed, and the resulting equations are reduced by the methods of least squares.

It is best to arrange matters so that the moon will be observed about the middle of the list. Its true time of transit may then be found as follows:

Let δ' be its apparent declination;
" δ_0 be its geocentric declination;
" π be its equatorial horizontal parallax;
" ρ be the radius of the earth for a point whose geographical latitude is ϕ;
" ϕ^1 be the geocentric latitude of the same point;
" λ be the increase in the moon's right ascension in one sidereal second;

T be the observed time of transit, and let

A be the true time of transit which is the moon's right ascension,

$$\text{Then } A = T + \Delta R + \left[a\frac{\sin(\phi - \delta')}{\cos \delta'} + b\frac{\cos(\phi - \delta')}{\cos \delta'} + \frac{c}{\cos \delta'} - \frac{.021 \cos \phi}{\cos \delta^1} \right] \left[1 - \rho \sin \pi \cos (\phi^1 - \delta_0) \right] \frac{1}{1 - \lambda} \pm \frac{S \sec \delta_0}{15(1 - \lambda)} \quad (7)$$

The last term may be found in the ephemeris; a, b, c, and ΔR are known from the star observations, which must be taken on the same evening as the moon transits, and δ' is found from the equation

$$\delta' = \delta_0 - \pi\rho \sin(\phi^1 - \delta_0) \quad (8)$$

A, the local sidereal time of transit therefore becomes known.

In the *Nautical Almanac*, under the head of "Ephemeris of the Moon for Greenwich," is given the right ascension of the moon for every hour of the year, Greenwich mean time. Looking for the right ascension nearest to A, we obtain the exact Greenwich mean time corresponding to A by interpolating with the formula

$$T_2 = T_1 + \frac{60(A - A_1)}{\Delta A} - \left[\frac{60(A - A_1)}{\Delta A}\right]^2 \frac{\delta A}{7200 A} \quad (9)$$

where T_2 is the required mean time corresponding to A;

A_1 is the right ascension nearest to A;

T_1 is the time corresponding to A_1;

ΔA is the differerence in right ascension for one minute taken from the ephemeris.

and δA is the difference between two consecutive states of ΔA.

This mean time (T_2) will be converted into the corresponding sidereal time (θ_0) by the tables of the ephemeris.

The difference between A and θ_0 is then the longitude required.

OBSERVATIONS.

The moon was observed on March the 11th, 12th and 13th, 1892, with a Fauth & Company portable transit of 26-inch focal length and 2-inch aperture. The observations extending but one day before and after full moon, both limbs were observed.

The order of doing the work was as follows:

(1) Read level;

(2) Observe group of six stars: two circumpolar; two between the pole and zenith; and two between zenith and equator;

(3) Observe moon;

(4) Read level;

(5) Reverse the instrument;

(6) Read level;

(7) Observe second group of six stars, arranged as in (2);

(8) Read level.

The object of all the operations except (3) and (4) was to determine the values of a, b, c, and ΔR of equation (4). In this case δR was inappreciable.

On the second night only ten stars could be observed on account of clouds.

To illustrate the work the reduction for one star is here given in full.

The lamp being *east* the first level reading on the third night gave the following results:

	E.	*W.*
	29.5	25.8
	24.0	31.0
	28.2	27.0
	26.1	29.0
Means,	26.95	28.20

The value of one division of the level is 0.163s, hence from equations (5) and (6)

$$\beta = \frac{d}{2}(W - E) = +0.103\text{s}.$$

The correction to be applied to β due to the inequality of the pivots has been found to be —0.011 s when the lamp is east.

$$\therefore b^{1} = 0.103 - 0.011 = +0.092\text{ s}.$$

The second star observed was *32 Ursæ Majoris* with declination $+65° \ 38'.8$. As b varied during the observations, a value had to be interpolated for each star between the first value above

(0.003 s) and the value derived from the readings after the set of stars had been observed. This gave $b = +0.069$ for this star.

The record of the transit was

Thread.		*Time.*	
I.—	10 hrs.	9 m.	37.1 s.
II.—	10	10	17.5
III.—	10	10	56.4
IV.—	10	11	36.2
V.—	10	12	15.1
Mean $= T_1 =$	10	10	56.46

As the lamp is east the collimation correction is +. As the star is observed at upper culmination the aberration is —. ϕ here $= 40° \; 36' \; 24''$.

Our data then give

$$\sin(\phi - \delta) \sec\delta = -1.02, \qquad \sec\delta = +2.42,$$
$$\cos(\phi - \delta) \sec\delta = +2.20, \qquad \text{aberration} = -.04,$$

and as found in the *Nautical Almanac*, page 332, is 10 hours, 10 minutes, 14.73 seconds. The rate is inappreciable.

Equation (4) then becomes

$$10 \text{ hrs. } 10 \text{ m. } 14.73 \text{ s.} = 10 \text{ hrs. } 10 \text{ m. } 56.46 \text{ s.} + \Delta R - 1.02\, a + \overline{2.20 \times .069} + 2.42\, c - .04$$

$$\text{whence } -1.02\, a + 2.42\, c + \Delta R \div 41.84 = 0$$

which is our final equation with this star, as the declination is $65° \; 39'$ it will have a weight of $\overline{0.46}^2$, the weight of a star in the equator being 1.00.

In this manner the following values were found for a and ΔR:

First night, $a = -.0975 \pm .061 \quad \Delta R = -41.6023 + .050$.
Second night, $a = -.2640 \pm .076 \quad \Delta R = -41.3561 \pm .060$.
Third night, $a = -.3029 \pm .072 \quad \Delta R = -41.0895 \pm .056$.

They appear to have varied somewhat uniformly from one night to the next. For c the mean of the three nights is used, as that is not liable to disturbance. The value is —.1913 clamp east.

Knowing the instrumental errors and clock corrections, we are now in a position to determine A.

The reduction for the third evening will be given in full. In

this case the moon was observed directly before the last group of stars; that is with the clamp west.

The record is

	Dark Limb.				*Bright Limb.*		
v	12 hrs.	11 m.	39.7 s.	v	12 hrs.	13 m.	41.0 s.
iv	12	11	56.4	iv	12	13	57.7
iii	12	12	13.1	iii	12	14	14.0
ii	12	12	29.1	ii	12	14	30.3
i	12	12	46.0	i	12	14	47.7
mean $= T =$	12	12	12.86		12	14	14.14

For convenience put $a_1 = 1 - \rho \sin \pi \cos (\phi^1 - \delta_0)$

$$B_1 = \frac{1}{1 - \lambda}$$

$F = a_1 B_1 \sec \delta_0$. Formula (7) then becomes

$$A = T + \Delta R + [a \sin(\phi - \delta^1) \sec \delta^1 + b \cos(\phi - \delta^1) \sec \delta^1 + c \sec \delta^1] F \cos \delta_0$$
$$\pm \frac{(S \text{ or } S_1)}{15 (1 - \lambda) \cos \delta_0}. \qquad (9)$$

For the Sayre Observatory $(\phi - \phi^1)$ has been found to be 11′ 22.19″, and the $\log \rho = 9.9993875$. From the *Nautical Almanac*, page 386, we find for March 13,

$\pi = 54$ m. 07.6 s., and $\delta_0 = + 2° 39' 50''.1$.

From page 45 we find for the above values of T that $\lambda =$ .0295 s., we have therefore

$$\phi = 40° \ 36' \ 24''$$
$$\phi^1 = 40° \ 25' \ 02''$$
$$\log \rho = 9.99939$$
$$(\phi^1 - \delta_0) = 37° \ 45' \ 12''$$

We now compute A_1, B_1, δ' and F.

$\log \sin (\phi^1 - \delta_0)$	$= 9.78694$	$\log \cos (\phi^1 - \delta_0)$	$= 9.89799$
$\log \pi''$	$= 3.51162$	$\log \sin \pi$	$= 8.19711$
$\log \rho$	$= 9.99939$	$\log \rho$	$= 9.99939$
$\log (\delta^1 - \delta_0)''$	$= 3.29795$		8.09449
(by equation 8)			$\therefore A_1 = .98757$
$\therefore \delta^1 = + 2° \ 06' \ 44''$			

$1 - \lambda$	$= \quad .9705$	$\log \cos \delta^1$	$= 9.99970$
$\log (1 - \lambda)$	$= 9.98700$	$\log F$	$= \quad .00786$
$\log B_1$	$= \quad .01300$		
$\log A_1$	$= 9.99456$	$\log F \cos \delta^1$	$= 0.00756$
$\log \sec \delta^1$	$= \quad .00030$	$F \cos \delta^1$	$= \quad 1.0176$
$\log F$	$= 0.00756$		

It will be noticed that in computing F we have used δ^1 instead of δ_0. This is quite accurate enough for the purpose and avoids troublesome reductions.

Using now the corrections for night three and remembering that the clamp is west,

$$
\begin{aligned}
a \sin (\phi - \delta^1) \sec \delta^1 &= - .1887 \\
b \cos (\phi - \delta) \sec \delta^1 &= - .0164 \\
c \sec \delta^1 &= + .1914 \\
\text{Sum} &= - .0137
\end{aligned}
$$

Sum $\times F \cos \delta_0 = K = -.01$, $\Delta R + K = -41.09$ s. $- .01$ s. $= -41.10$ s. which being added to T as shown in equations (9) gives

$T^1 = 12$ hrs., 11 m., 31.76 s. for first limb,
$T^1 = 12$ hrs., 13 m., 33.04 s. for second limb.

To reduce these times to the time of transit of the moon's centre, the first must be increased by the quantity $\dfrac{S_1 \sec \delta_0}{15\,(1 - \lambda)}$ and the second diminished by $\dfrac{S \sec \delta}{(1 - \lambda)15}$. This last quantity is found on page 385 of the *Nautical Almanac*. Its value is 60.97 s. This value when multiplied by $\cos x$, will give the correction to be applied to the defective limb by equation (2).

To apply equation (1) we reduce our sidereal time (T) to mean time, and interpolate in the ephemeris of the sun, on page 39 of the *Nautical Almanac*, to obtain the sun's right ascension and declination. This gives

$$d_s = 23 \text{ hrs. } 38 \text{ m. } 24 \text{ s.} \quad \delta_s = -2^\circ\ 23'\ 16''.$$

From page 386 the moon's approximate right ascension is found $d = 12$ hrs. 12 min. 45 sec. From which $\frac{S_1 \sec \delta_0}{15(1-\lambda)}$ follows at once, its value being 60.29 s.

Applying these corrections to T gives

$\begin{cases} A \text{ from dark limb} = 12 \text{ hrs. } 12 \text{ m. } 32.05 \text{ s.} \\ A \text{ from bright limb} = 12 \text{ hrs. } 12 \text{ m. } 32.07 \text{ s.} \end{cases}$ the final values of the right ascension of the moon's centre.

These are finally to be compared with the Greenwich time corresponding to this position.

From the ephemeris, page 45, we find the nearest value to these to be

$$T_1 = 12 \text{ hrs. } 11 \text{ m. } 13.08 \text{ s.}$$

and the other quantities of equation (9) are

$$\Delta A = 1.7725 \text{ s.};$$
$$\delta A = .0009 \text{ s.};$$

which substituted in (9) give

$$T_2 = 17 \text{ hrs. } 44 \text{ m. } 32.69 \text{ s.} \qquad 12 \text{ hrs. } 44 \text{ m. } 33.37 \text{ s.}$$

To convert these mean times into the corresponding sidereal times, we increase them by the right ascension of the mean sun for March 13, as found on page 39 of the ephemeris, and also by the quantities taken from Table III of the appendix. We then subtract the values of A from the sums respectively, and the remainders are the two determinations of longitude as obtained separately by the two limbs.

$T_2 =$	17 hrs.	44 m.	32.69 s.	17 hr.	44 m.	33.37 s.
From III =		2	54.89		2	54.89
R. A. of mean sun =	23	26	18.82	23	86	18.82
$\theta_0 =$	17	13	46.40	17	13	47.08
$A =$	12	12	32.05	12	12	32.07

$$\therefore L = +\ 5 \text{ hrs. } 01 \text{ m. } 14.35 \text{ s.} = +\ 5 \text{ hrs. } 01 \text{ m. } 15.01 \text{ s.}$$

This result is subject to another very considerable error not yet noticed.

The perturbations and disturbances in the case of the moon are so many and so complex that it is impossible to compute her exact position in advance. The position given in the ephemeris

is not even so accurate as it might be made by longer computations. It is possible that the position there given may differ from the true position by so great a quantity as 0.8 s. Since an error of only one second in the moon's right ascension makes an error of longitude of 27 seconds, it is evident that this method may be used only when an approximate result is desired. For, however well the results obtained may agree among themselves, they may safely be assumed to be liable to an error of at least 9.00 seconds, owing to the errors of the ephemeris itself.* The personal equation, too, here makes itself felt with its effect magnified twenty-seven times.

The final results of the three nights are as follows:

Bright limb,	5 hrs.	1 m.	19.97 s.	First night.
Dark limb too ragged to be observed				
Bright limb,	5 hrs.	1 m.	23.38 s.	Second night.
Dark limb,	5	1	25.54	
Dark limb,	5	1	14.35	Third night.
Bright limb,	5	1	15.01	

Mean = + 5 hrs. 01 m. 19.74 s. $\begin{cases} \pm 3.41 \text{ s. error of observation.} \\ \pm 9.00 \text{ s. error of ephemeris.} \end{cases}$

The error of observation is therefore $\frac{4}{5}$ miles and of the ephemeris $2\frac{1}{4}$ miles.

The true value of the longitude as determined by occultations is + 5 hrs. 01 m. 31.85 s., which differs from the one here obtained by about three miles, a result to have been expected.

ERIC DOOLITTLE, '91.

March 28, 1892.

* For a discussion of the laws according to which these errors vary in magnitude, together with a scheme for eliminating them, see the U. S. Coast Survey Report for 1854, Appendix No. 36.

STREET RAILWAY WORK.

The National Street Railway Convention, which met in Pittsburg last November, unanimously decided that "the mule must go." In fact, at the time of this convention, the mule, as a factor in street car locomotion, had almost vanished. His place is now principally filled by what Bill Nye calls "a streak of lightning." Electricity has not only accomplished this, but it has put a check on the popularity of the cable line. One reason for the latter is that the first cost of the electric track is only one-ninth of that of the cable, so that, although the cost of the electric power plant may be slightly the greater, the total first cost of the electric system is much the less.

As to the working expenses per car mile, there is but a slight difference between the two roads. In localities where heavy traffic, steep grades, and frequent stops are to be dealt with the cable road still finds favor, but in rural districts, especially where long runs and uncertain traffic abound, the electric stands alone. No other system can run all its cars to the picnic grounds one day, to the horse races the next, and to the circus ground the following day without endangering its elasticity. On January 1, 1892, there were 3099 miles of electric road in operation, and only 660 miles of cable. Operating expenses for the electric road vary all the way from 8 to 15 cents per car mile. Crosby and Bell, in their excellent work, give an average of 11.33 cents per car mile, and their itemized estimate shows that while only 1.35 cents are involved in the cost of the power itself 1.08 cents are directly and 1.72 indirectly involved in repairs due to imperfections of track. Here is a field for the economy of the civil as well as for the electrical engineer.

The recent decision from a New York court in defence of overhead wiring establishes it as the future method of conducting the current. Philadelphia is soon to be wrapped in a network of these wires, and Boston is already so. The danger attending them does not exist so much in their liability to break as in the

liability of other wires, broken by storms, to fall over the trolley wire and transmit the current to the traffic below. In this way horses are frequently killed, but, strangely enough, few fatal accidents from this cause have befallen the human race. This is no doubt due to the comparatively low conductivity of the human nerve. The voltage in a trolley current is seldom greater than 500, so that the danger is great only when the person is standing on wet ground or other good conductor.

In building a road, the iron work is generally purchased from dealers and manufacturers at a rate per foot of track. For first-class work this amounts to about 85 cents. Other special work, such as curves, turnouts, crossings, etc., is furnished by contract. There are three firms in this neighborhood that make a specialty of street car work. Wm. Wharton, jr., & Co., of Philadelphia, have a reputation of long standing. The Johnson Street Railway Company, of Johnstown, Pa., is well known throughout the United States and has exerted an influence in bringing about the revolution in street railway construction. The Tramway Rail Company, of Pittsburg, although a young firm, has taken hold of the subject in a commendable way, and shows a disposition to analyze the details of the work only in the light of engineering and of the most recent requirements. Being untrammeled by old antecedents of practice, and being seconded by the able lieutenantcy of the Union Switch and Signal Company, they are well fitted to do this. Thanks are due them for the accompanying illustrations. The following is a synopsis of the details of track work.

Street railway gauges were formerly 5 feet 2½ inches, but lately the ordinary railroad gauge, 4 feet 8½ inches, has come into practice. Until a few years ago the flat steel tram rail was universally employed. It was about 1¾ inches high by 5 inches total width. Its support was a 5 x 8-inch longitudinal stringer of timber, to which the rail was spiked. The timber quickly decayed, allowing the ends of the rail to work up and down with each passing car. Iron plates under the joints did not remedy the evil, so today the girder rail (Fig. 1), which approaches the T rail in section, is mostly used in new work. This rail is made

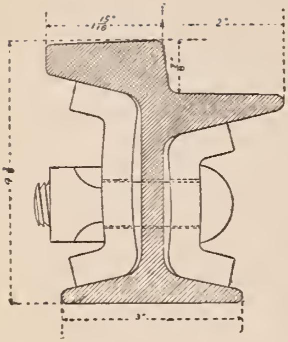


FIG. 1.

as wide as possible in the upper flange, so that paving stones will fit up close at the top without cutting away for the lower flange.

Where paving is not required, a T rail is used. It would seem that street rails should be much lighter than steam rails, because the traffic is very much lighter; in reality, there is not much difference. The average weight of a street rail is probably 60 pounds, while that of the steam rail would approximate 90 pounds. The Johnson Company has demonstrated that it is poor economy to use a rail for street car purposes weighing under 40 pounds per yard. The diminished spacing of ties would so increase the cost of labor and material as to more than make good the expense of heavy rails. Ties are spaced 3 to 4 feet from centers. Where the street is paved, or where a probability of paving exists, the rail is carried on chairs, which rest on the cross-ties and are spiked thereto.

These chairs are now mostly made of soft steel, and are formed from red-hot plates by a single stroke of the drop forge. This not only moulds them into their general shape, but, in the Johnson chair, punches out two small lugs which grip to the lower flange of the rail and hold it in position. In another variety of chair, shown in Fig. 2, the lugs are formed by running a hot strip of iron through holes in the sides of the chair and bending the ends over the top so as to catch the rail. Many other forms of soft steel chairs are in use, as well as a variety of cast-iron shapes. The failure of cast-iron to give satisfaction is partly due to its rigidity. When a steel chair is being applied to a rail it is turned to an angle of 45° with its proper position. The rail then sits flat on its chair seat, but the lugs do not touch it. Now, as the chair is turned back to its proper position, the lugs pass over and are sprung up by the rail flange. Generally, a hammer is used to drive it to position, giving the lugs that elastic grip which is the enemy of wear and tear. Cast-iron chairs, on the

other hand, are usually fastened to the rail with bolts in various ways. Not only does the hole in the chair grow larger, but, under the ceaseless hammering from above, the bolts have been found in some cases at the rail-joints to be worn to less than three-fourths their original diameter. Besides the objections due

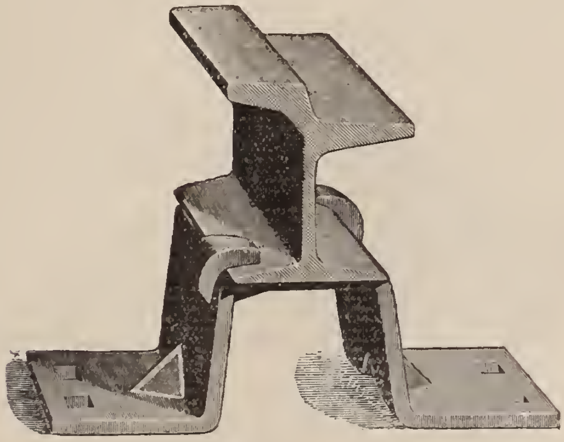


FIG. 2.

to wearing and looseness, cast-iron chairs are open to those of increased cost and difficulty in setting up.

The common size of chair is 4 inches length by 4 inches height, the width corresponding to that of the lower flange of T rail for which it is designed. Where two rails meet at a joint the length of the chair used is sometimes increased to 7 inches. In this case two ties are placed side by side under the chair. Since the lowest girder rail section in common use is 4⅜ inches, and the height of the chair is 4 inches, if we allow the usual ½-inch projection of the paving above the top of rail we have a total distance of 8⅞ inches as the depth of the tie. If the ordinary 4 x 6 x 8-inch paving block be used there is room for ⅞ inches of sand between the stone and tie. In cases where brick or asphalt paving obtains, or where there is no paving whatever, the rails are frequently placed on flat tie plates, which are stamped with lugs similar to chairs, and spiked directly to the ties. In the latter case the rails will be firmly held against

any tendency to spread, but when placed on chairs they should be stayed together with tie rods spaced about ten feet. Where rapid transit and sharp curves are met with there is considerable lateral thrust. This is counteracted by reënforcing the chairs and tie plates with braces, which give the rail a support directly under its head. (Fig. 3.)

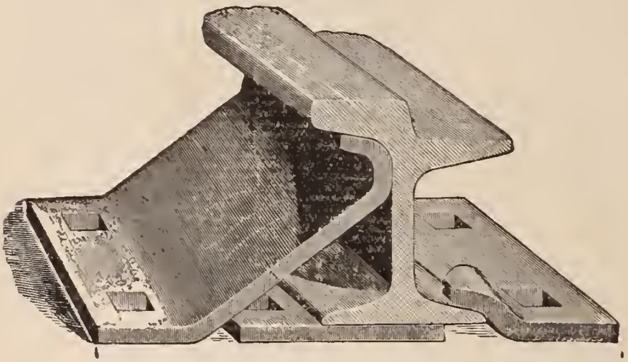


FIG. 3.

The question of curves is very important where narrow streets occur. Sometimes this point exerts great influence on the route to be followed. On cable lines the curves can be made much sharper than on electric. The minimum radius for the former (measuring to the center between rails) is about 27 feet 6 inches, while for the latter it is about 35 feet. Sharp curves, however, are neither economical in wear nor pleasant for passengers. One way of alleviating these evils is that now being introduced by the Tramway Rail Company.

The curve is compounded, having large radii at the beginning and ending, while the radius at the middle is made small. This compounding system can be carried to any extent desired, but for ordinary work three radii, giving five different segments, will be found sufficient. The merit in this scheme depends on the fact that the shock which a car receives on passing from a straight to a curved track varies directly as the radius of the curve track. By using a large radius at the beginning and shorter ones toward the center of the curve, a passing car will receive about six small shocks, occurring at the junction of the different segments, while

with the simple small radius curve the car receives a single great shock at each end of the curve. That this innovation is an improvement will certainly be assented to by the passengers, and especially by those lady passengers who are averse to carrying the traveling public in their laps without the exchange of either permission or warning.

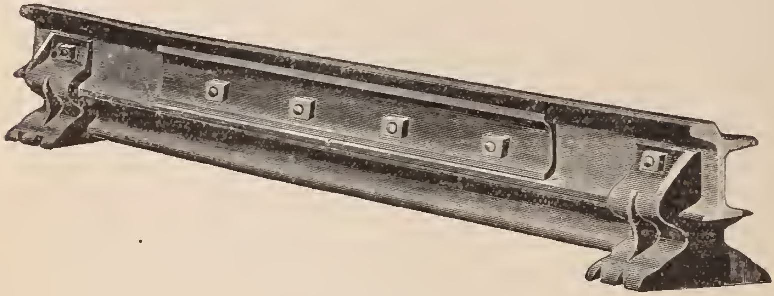
Street railways are not pitched at curves as steam railroads are, but they are supplied with guard rails, which answer the same purpose, though with considerably more friction. The guard is sometimes rolled directly on the rail itself. In other cases the guard consists of a vertical bar of steel, about 1 x 4½ inches in section, which is bolted to the rail and held in position by cast-iron chuck blocks. The latter guard is only used because the former is a very difficult shape to roll. The following is a common rule for guarding curves with respect to their radii:

Radii	under	45 feet	require guard on both rails.	
"	"	125 feet	"	" " outside rail.
"	over	125 feet	"	no guard rail.

These figures, however, are governed by the rate of speed of cars. The average radius is about 45 feet, but 65 feet is not unusual.

Probably the most important subject with which street railway engineers are engaged is that of rail joints, and indeed this is a vital question in steam railroad engineering. The joint now mostly used is the tie joint, where the rails meet over the center of a tie. Of course, splice bars are bolted to each side of the rails, as shown is Fig. 1. This style of splicing is especially good, since the rail ends are held rigidly in position by the upper and lower edges of the splice bars and not by the direct action of the bolts. The only office of the bolts is to draw the two splice bars tightly together. But, however rigidly this clamping may be done, it can not give to the joint that stiffness which belongs to the rest of the rail. The rail acts as a continuous beam, and since the ties are spaced 3 to 4 feet from centers the deflection becomes considerable. Moreover, the deflection in the end span is greater than in the intermediate spans of the rail, the ratio being about 3. This has the effect of giving a slight

blow to a wheel passing over the joint. The suspension joint, where the rails meet at a point midway between two ties, avoids this trouble, but it induces another. The rail is weakened at the joint. Probably the best device for meeting this trouble is the compound chair designed and manufactured by the Tramway Rail Company and illustrated in Fig 4. It consists of a piece



FIG, 4.

of T rail, on each end of which is cast an iron chair. The latter furnish a support at the ties while the former bridges the space between ties and presents a continuous bearing for the street car rail above it. Rail joints, although apparently a simple matter, are the cause of much annoyance to traction companies. On some roads the joint is encased in a cast-iron box with a lid over it, so that the bolts can be screwed up when they have worn loose.

A very annoying joint trouble that came under the notice of the writer was that of the Duquesne Traction Company, of Pittsburg. Their track was laid with the Wharton rail, which has no lower flange. Its general section was similar to a T iron, the flange being on top. It was carried by a special cast-iron chair, which supported the rail under its head. It was easy enough to hold the rail up, but it was next to impossible to *hold it down*, owing to the fact that, its lower flange being gone, there was nothing left for the chair to grip to. The splice-bar fit spoken of above was not applicable here and consequently the joints, being loosened by the shock from passing cars, were soon flying up and down in the full enjoyment of American freedom. The tie below the joint was battered so that its bed was destroyed.

The whole road was in very bad condition, although its age was less than two years.

The modest opinion of all street car passengers is that street railway crossings are mean, nasty things—especially when they occur at a railroad crossing. In this opinion engineers agree with the public. The main trouble with crossings over a steam road is that railroad companies, having an earlier franchise, as a rule are not inclined to be at all courteous to their insignificant cousins and, perhaps, competitors. Unless a street railway company approaches the other in very sugary terms they may expect more or less opposition, and in few cases can they so much as touch the steam railroad track. In this event the required style of crossing is called the jump-over crossing. The street railway extends up to the steam rail, where it stops. Between the steam rails it takes up its course again, and again on the other side of the second rail, the steam rails not being cut or tampered with in any way. There are a number of considerations entering into the design of a crossing over a steam road which makes a complex thing out of an apparently simple one. An ordinary locomotive driver wheel is allowed to become worn so that before it is discarded there is a hollow or channel-like depression in its wearing surface amounting to ⅝ of an inch in depth. Therefore, all iron work near the rail must be kept ½ inch below the head of the steam rail. In an ordinary jump-over crossing without special fittings this takes ½ inch to the height which must be cleared by the street car wheel, making 1⅛ inches in all. Then the locomotive driver is allowed to shift sideways on the rail, its limiting positions being such that the rail is just barely covered by the driver. This position occurs when the locomotive is rounding a curve whose radius is the minimum for which the locomotive was designed. But on a straight track there is considerable play, as the wearing of any railroad crossing will show. This requires that iron work shall be kept below the head of the steam rail for a distance outside that rail of at least 4 inches. Encroachments upon these figures are liable to result in battered iron work and loosened joints for the street railway, while the steam railroad has been known to suffer wreckage from this cause. Exceptions to the above are true when the iron work is

of such strength and design that the locomotive wheel can run upon it instead of upon the rail, and when this can be done without impact. In Fig. 5 is an illustration of probably the best form of crossing. Its principal feature is that the steam rails are bolted to and that a small notch, about ½ inch deep by 1¼ inch wide,

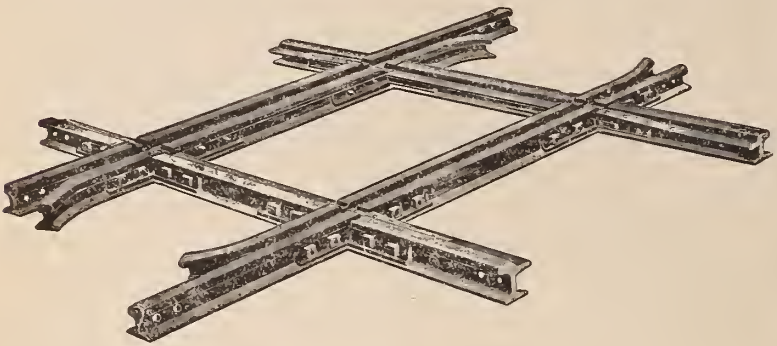


FIG. 5.

is cut in the top of the rail, allowing the flange of the street car wheel to pass through. These concessions are now being granted by some railroads, notably the Pennsylvania systems. The points noted above are heeded in this design, and the iron work outside the steam rail is kept ½ inch below the head of the latter. The street car wheel runs on its natural face until its flange strikes the wedge-shaped piece of steel shown on top of the tongue of the street rail. The wheel then runs on its flange over the wedge-shaped piece and through the notch in the steam rail, being raised during this time a distance of about ⅝ inch. Jumping the 2½-inch throat between the steam rail and its guard rail, the wheel strikes its own rail again and continues to the other steam rail, where the action is reversed.

Trouble with street railway crossings in general is due to their imperfect foundations and the flimsy nature of their connections. These latter should be made extremely heavy, since the point to be aimed at is not merely strength, but rigidity. Bolts ⅞ inch in diameter are not too heavy. The angle bars might be made of ¾-inch stuff and should fit on the same principle as the splice bar. An instance is cited of a multiple crossing in Chicago which resisted all ordinary efforts to keep the pieces in position.

Finally the crossing was literally loaded down with massive connections, and no trouble has been experienced since.

A spring tongue switch is shown in Fig. 6. This design carries out the idea above mentioned, and secures rigidity by means

FIG. 6.

of massive proportions. The tongue is of rolled steel, while the remainder of the switch is cast from a mixture of steel and cast iron called semi-steel. This material has the merit of combining hardness with toughness, the two requisites for a good wearing material. This tongue is firmly held in position shown by a very strong spiral spring contained in a box cast for it on the under side of the switch. The spring holds a vertical pin, which is in turn keyed into the tongue. A wheel approaching from the right of the figure and back of the tongue would force it open, but the spring would afterwards draw it back. This meets all the requirements on double track roads and in turnouts. In other cases the tongue is left loose and is operated by hand.

Switches should have large radii. Those with small radii jerk the car about in an unpleasant manner according to the principle mentioned under the subject of curves. A large radius switch at the beginning of a curve acts as an easement.

These are some of the points met with in designing. New ones are brought into consideration every day, and there are few better opportunities for a young engineer to grow up with a subject than those found in this kind of work. Some of the questions to be settled are the following:

Should a guard ever be placed on the outside rail of a curved track?

Can not the wear and tear of a track be lessened by supporting rails on chairs with a bearing of wood?

Should not tie joints be abandoned in favor of suspension joints?

What is the ideal section for a street rail?

Can iron ties be substituted for wood with a saving in cost and wear?

Can not a wooden stringer be laid lengthways under the rail and over cross-ties so as to take the place of chairs, give stiffness at the rail joint, and decrease cost?

This is done in certain electric roads of Boston.

WILLIAM Y. BRADY, '92.

PRACTICAL APPLICATION OF THE ELECTRIC MOTOR.

In the early part of the present century a discovery was made in England by William Sturgeon which may be regarded as forming the basis of the great development we have seen in electrical science in the past fifty years. About the year 1825 he found that a bar of non-magnetic iron, or steel, may be strongly endowed with magnetic properties by the passage of a current of electricity through a strip of copper, or other conducting material wound around the bar. The wonderful history of the electro-magnet dates from that time.

This discovery was very soon followed by another of scarcely less importance. In 1831, Faraday in England and Henry in this country, working entirely independently of each other, found that a current of electricity could be generated in a copper wire, or any other conductor, by simply moving it in a magnetic field.

For half a century electricians have worked in experimental lines upon the principles embodied in these discoveries, and the student of today can trace, in their results, the evolution of our modern types of dynamos.

About the year 1833 Henry found that the converse of his discovery of two years before was also true, *i.e.*, that motion may be imparted to a conductor at rest in a magnetic field, by passing an electric current through it. It was not, however, until 1873 that the electric motor assumed much prominence. In that year Fontaine conceived the idea of running one dynamo by a current derived from another of similar construction, operated by a

steam engine. The total length of the conductor interposed between the two machines was over two kilometers, and this experiment demonstrated to Fontaine that mechanical energy can thus be transmitted over considerable distances by means of two dynamo electric machines and a conductor. This discovery opened a new field to electric engineers, and the usefulness of the electro-motor very soon began to be appreciated.

When a new invention is brought into public notice in a field in which it has many rivals, it can not be viewed by itself alone, but a comparision must be made of its merits and those of appliances already in use. The number of systems of power transmission that existed before the invention of the electric motor was not only very large, but several of them had been brought to quite an advanced state of perfection. When the distance is very short, as, for instance, to machinery in different parts of a factory, transmission by shafts and belting has been, until recently, the most practicable method of conveying power to machines; but the experience of the past two or three years has proved that every form of machinery can be run successfully by electric motors. There are now several important manufacturing establishments where the electric transmission of energy is largely used. Especially is this so in France, where in large engineering works separate motors are employed to run detached pieces of machinery, which may be placed in any part of the building without regard to the location of the engines and boilers, or lines of shafting. A few enthusiastic advocates of the old system assert, in argument against electric transmission, that the efficiency obtained is not greater than fifty per cent. This is probably true, but they forget that the total efficiency of transmission by shafts is generally *less than fifty per cent.* because of the immense weight of the parts which must be continually kept in motion whether the total amount of machinery is in use or not. It may be argued that, as the total efficiency of transmission is no greater with electricity than with shafts and belting, the former has no just claims to superiority; but the advantages of electricity are its simplicity and cleanliness. There is no necessity for heavy buildings to support the machinery of transmission, the cost of attendance and repair is greatly reduced, and by the elimination of that network

of rapidly moving belts and pulleys, which is necessary in the old system, and which has been a prolific source of accident, the care of the machinery has been made a comparatively safe task.

"With electric transmission* no power is consumed, and none is transmitted for those tools which are idle: and the power transmitted is always proportional to the amount of work they are doing. It is this peculiarity of electric transmission, that the power consumed is always proportional to the work performed, which render it on the whole more economical than some other and purely mechanical devices."

Notwithstanding that the loss between the engine and lathe, or other machine, is probably fifty per cent., still electric motors are economical. Heavy main shafting running all day is thus avoided. Ordinary main shafting, with the belts, probably absorbs thirty per cent. of the power transmitted, especially when the alignment is faulty, which is almost invariably the case. The expense of electric power in the first instance is no greater than the present method of obtaining power in a factory, and the difficulty of maintaining regularity of speed with motors is purely imaginary, for, in practice, no trouble is experienced on this head. To give a practical case where the speed of the motor does become considerably altered by the variation of the work put upon it, and when it proves of advantage—when a fine, light cut is taken in a lathe, much greater speed is desired than when taking a large and heavy cut. In the latter case more power is also required. Now these two alterations in speed and power are exactly what may be obtained from a motor without any adjustment, since, in any motor, for small power it runs faster and takes less current than when doing heavy duty. For any particular class of work, by inserting resistances with a hand switch, almost any desired speed can be had.

Whether or not this new system of transmission is destined to come into universal favor as a means of conveying power to different parts of a building is a question which only enthusiasts attempt to answer, but certain it is that the electric motor is

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* Gishart Kapp. "Electric Transmission of Energy."

rapidly gaining friends and inspiring confidence by the excellent results obtained by its use.

The practical difficulties attending any and all systems of transmission increase with the distance over which the power is carried, and the use of the revolving shaft for such purposes is very soon rendered impossible. When the distance is greater than one and three-fourth miles the shaft can not be turned from one end, for the torsional moment which it is safe to apply is not sufficient to overcome the frictional resistance of the bearing.

While for electricity the difficulties encountered increase with the distance, such increase is not as rapid as with purely mechanical devices; therefore, long distance transmission seems to furnish the most promising field. In dealing with long distance transmission only two systems present themselves as worthy of serious consideration:

1. The electric transmission of energy.
2. The wire rope transmission of energy.

A careful comparision of these rival systems has been made for distances varying from 100 to 20,000 meters, and it is found that up to 1 kilometer (five-eighths of a mile) wire rope transmission is more economical than electricity; while above that limit the reverse is true. An explanation of this is to be found in the fact that the cost of installation is great in the electric system, owing to the high price which must be paid for dynamos and motors. For very short distances this cost exceeds that of the installation of a wire rope plant; but as the distance increases above one kilometer the cost of the wire cable exceeds that of the copper conductor, which is the only additional expense worth reckoning, connected with the electric system.

We thus see that for distances greater than, say, one mile the electric transmission of energy occupies the field without competitors, and where water power is available as a prime mover power can be furnished from a central station, at very small cost, to receiving stations situated over a wide range of country. It is obvious that transmission of power will pay only in cases where the cost of generating it by a local engine will exceed that of the transmission; but water power costs only about one-seventh as much as steam power, and in *all cases* it is

cheaper to transmit such energy than to generate it at the receiving station. The same is true when the prime mover is steam, provided the engine at the generating station is of large capacity and the power derived at the receiving station is less than 10 horse power. Beyond that limit a local engine is more economical.

Owing to its inexhaustible water power, Switzerland has been the seat of the greatest activity in this new branch of electrical science, and it was there that all the early experiments were conducted; but America, with her Niagara and the falls of her Western mountain ranges, offers a still more promising field in which to determine the possibilities of the electric transmission of energy.

Having seen that mechanical energy can be delivered to machinery at a distance from the prime mover by electric transmission, we can consider the application of the electric motors to railways. Here again the wire rope, moving in underground conduits, asserts itself as the only opponent of the motor deserving mention (assuming, of course, that the days of the horse cars are passed); but, as we shall see presently, certain conditions may prevail when these two systems cease to be rivals and each occupies a separate field.

Two cities in this country have given the cable system a thorough trial. Chicago has been operating thirty-eight miles in her streets for several years, and in San Francisco seventy-five miles have been in use long enough to form a good estimate of its worth. In the former city it has proved rather unsatisfactory for several reasons, of which the following are the most important:

1. The cable usually "frays" to a certain extent upon the outside, owing to the action of the "friction clutch" upon it, and often the clutch becomes entangled and the driver can not disengage it in time to prevent collision with objects on the street.

2. The cable moves with a stated velocity, which must always be the speed of the car. When a car has been detained in a a crowded street, it is impossible to make up time in the suburbs on this account.

3. The cable moves only in one direction, hence the car can not be reversed without the aid of horses.

4. Recent practice is to run the cable around a single pulley in

turning a street corner, and not allow it to follow the curve of the track. The car must, therefore, be carried around the corner by its own momentum, and if stopped can not be started again without the aid of horses.

In the crowded streets of Chicago these defects have caused considerable inconvenience, and there is serious talk of replacing the cable roads by others operated by electricity. In San Francisco, however, the conditions exist under which the cable system is the best that can be employed, *viz.:* heavy grades of *ten* per cent. or more. A cable several miles long, moving with a velocity of twelve miles an hour, possesses in itself a large amount of momentum, which acts in the same manner as a heavy fly wheel. Loaded cars starting on heavy grades produce very sudden fluctuations in the amount of power consumed, and the moving cable serves to protect the engines from these sudden changes. The electric system can meet all such requirements for grades of not greater than *twelve* per cent., but the cable is really to be preferred where the grade is above *ten* per cent.

Three systems of distribution have been attempted in connection with electric roads in this country, but at present the "trolley" system is the only one that is meeting with any practical success. The storage battery system has been thoroughly tested in some cities, but has been virtually given up on account of the inability of manufacturers to make a storage battery "hardy" enough to stand the wear and tear of street railway service. The method of running the conductors in underground conduits has been tried by Bently and Knight, but after long and costly experimenting all such roads have been given up. In Buda-Pesth the system has proved quite successful, but the peculiarities of our climate make it impossible, by any methods known at present, to preserve a perfect insulation of the underground cables. Mud and water find their way into the tube containing the bare conductors, through the open "slot" at the top, and short circuits invariably ensue. It is probable that improved methods of insulating the cables will be found, and in such case the underground system can not fail to become popular on crowded streets.

As to the trolley system of distribution, a great deal has been

written recently concerning the danger connected with its use. This is unfortunate, as there is not a case recorded of a death resulting through the agency of the 500 volts employed. In a few cases, in small cities, the opposition to the trolley has been sufficiently strong to carry its point, and "that mysterious agent which kills without a moment's warning" has been forbidden to enter; but the progressiveness of nearly all our large cities is attested by the complete triumph of the trolley system, and in New York, Brooklyn, Philadelphia, Buffalo, Cleveland, Cincinnati, and many other places the electric car can now be seen upon the streets.

Great advance has been made recently in the design and construction of motors for street railway service. From the high speed, double reduction type, which rattled away with their complicated gearing a few years ago, we have passed to a slower speed motor, with single reduction gear, which is found now upon most roads. Indications point, however, to a new type of slow speed motor—the gearless—which is either keyed or fastened with springs directly to the axle of the truck. The Short and the Westinghouse Companies have perfected gearless motors which are working successfully on several good roads. Freedom from noise is obtained by this ideally simple device, as no speed reduction gears are present.

POWWOWING.

There is practiced, both in Bethlehem and the country roundabout, a sort of faith cure called powwowing. It is almost impossible to obtain exact information on the subject, as many know of it only by hearsay, while those who can give information do not seem so inclined. The writer was directed to people said to be excellent powwowers, but when these persons were approached on the subject they invariably denied all knowledge of it. Whether it was due to misinformation or not it is impossible to say.

The word powwow immediately suggests it to be of Indian origin. Webster defines powwow as "Conjuration performed for the cure of diseases and other purposes, attended with great noise and confusion, and often with dancing."

There are many references to powwowing in old books which show that the name, if not practice, is strictly the property of the North American Indian.

Roger Williams published, in 1643, a book entitled a "Key into the Language of America." It is divided into sections, labeled, "Of Religion, Soules, etc.," "of Sicknesse," "of their Coyne," etc., and it is under the first two that some interesting facts are found. Under "Religion" he defines Pow-wáw, a Priest, and Pow-waûog, Priests, and in his observations, that the Pow-waûogs "doe begin and order their service, and Invocation of their Gods, and all the people follow, and joyne interchangeably in a laborious bodily service, with sweating, especially of the Priest, who spends himself in strange Antick gestures, and actions even unto fainting. In sicknesse the Priest comes close to the sick Person and performs many strange Actions about him, and threatens and conjures out the sicknesse."

Under his observations on sickness: "Their Priests and Conjurers (like Simon Magus) doe bewitch the People, and not only take their Money, but doe most certainly (by the help of the Divell) worke great Cures, though most certaine it is that the greatest part of their Priests doe merely abuse them and get their money in times of their sickness, and to my knowlege long for sick times, and to that end the poore people save up their Money and spend both Money and Goods on the Pow-wâws or Priests in these times, the poore people commonly dye under their hands, for, alas, they administer nothing but howle, and roar, and hollow over them, and begin the Song to the rest of the people about them, who all joyne (like a Quire) in a prayer to their gods for them."

In "Old Indian Chronicles" with "Notes by Drake" there are found many quaint and odd descriptions of early colonial days as connected with Indian life. Dr. Cotton Mather was very decided in his views on the subject and solves the problem of the settlement of the New World by the Indians in a most

original way. He was certain that the wretched heathen were decoyed hither by his satanic majestic in hopes that they would never hear the Christian Gospel, and so cause him to loose his power over them, and describes their religion as a devil worship. It must be said that the religion of the Indians was very little understood, and that their powwows and conjurers were looked upon by our forefathers with a religious horror, bordering on fear.

In 1620 the Pilgrims landed, but did not mix with or have any transactions whatever with the Indians, and it was to this end that in "March, 1621, the powwows of all the Indian tribes assembled in a dismal swamp and for three days together held their mysterious conjurations to find out the intentions of the English. The English, however, were at a loss to know what the powwowing affair meant, though they did not hesitate to pronounce it something diabolical, and that it had special reference to them and their coming into the country." The Pilgrims were somewhat relieved, when about a month later Samoset, an Indian, approached their village and uttered in a loud voice, "Welcome, Englishmen, welcome!" This meeting or assembling of the powwows seems to have been for an unusual purpose, that is, to inquire into the future.

The religious services or exercises were led by the powwows or priests. "The Indian powwow was a physician as well as a priest. In every case of sickness he was sent for to come to the cabin of the sufferer, where his mere presence, or if that failed, the magical incantations were thought sufficient to restore the invalid. The credulous historian of the Narragansets, who was frequently a witness to these superstitious rites, acknowledges that 'by the help of the devil, they do most certainly work great cures,' although 'they administer nothing, but howl and roar and hollow over them.'"

On the night of August 28, 1675, a terrible storm arose that drove many vessels towards Cambridge (Mass.) and some towards Muddy River. The storm was so violent as to blow down wharfs and houses. The Indians afterwards claimed that they had caused the storm by their powwow.

The early settlers, another authority claims, never noticed that

the Indians had any religion but what was diabolical and uncouth, as if the devil himself had devised it and gave it to his faithful Indian followers, to proclaim it. "They used to call powwows by some kind of familiarity with the devil, and to whom they used to resort to for counsel in all kinds of evils, both corporal and civil."

It is not attempted to show by these references to musty books that powwowing, as practiced at the present time in this locality, is at all related in principle to the powwowing of the Indians, but from what has been said and from what is to follow it is certain that the outward observances are somewhat similar, that is to say, coming close to the afflicted one, saying certain formulas and going through certain motions, and are related to the Indian practices. It will be noticed that powwower and powwowing are used as indicating the actor and the action. A powwow doctor or a powwower indicate or name the same person. A powwower, as understood now, is one who has the power, by going through prescribed forms, to remove pain.

The powwowers do not claim to cure any or all disease, nor, as far as is known, to cure hurts and injuries. They simply claim to remove pain and allay suffering. Some simply powwow erysipelas, others scalds and burns, while still others stop the flow of blood and remove rheumatism. The proceedings are similar for all, varied somewhat by different persons. For example, one powwower, in removing the pain of erysipelas from the face, took an oak splint two feet or more long, lighted one end of it, forming a glowing coal, and passed it over the face near enough for the sufferer to feel the heat. The motion is somewhat circular, and is repeated three times, then the powwower blows on the afflicted part three times; then three times more passes the stick as before, blows three times; passes the stick three times, blows three times, and the operation is completed.

As can be seen, the whole performance is founded on doing certain things three times, the operator repeating certain words to himself three times as he passes the stick over the part the three times. What the formula is, is known only to the initiated.

For stopping the flow of blood, the hand of the powwower is passed over the bleeding part three times and blowing three

times. The hand is close to but does not touch the person. A well known business man in Bethlehem, who had been powwowed for flow of blood, stated that as near as he could remember the formula was "Father, Son, and Holy Ghost," repeated each time the hand was passed over the bleeding part.

The operation of removing pain from scalds and burns is similar. The formula is "Three maids went over the land. One carried a fiery chunk, the other said, "Don't;" the other said "Take the pain away, and name the Father, Son, and Holy Ghost."

The powwower does not acquire the power of powwowing by simple practice or knowledge, but must receive the gift from some aged powwower who thinks his life is nearly finished and can not live much longer. If it is an old man who is to transmit the gift, he tells the secrets to a woman. If it is an aged woman she tells it to a man. The power would be lost if a woman were to tell a woman or a man tell a man. After one person has told another the gift of powwowing no longer exists for him who has given the charm away. The formula used is kept a secret not to be revealed. There is no regular price charged by a powwower, but the patient gives whatever is thought just.

Some powwowers can only treat at certain stated times. On the Delaware River lives a noted powwow doctor, who treats only on one day—the first Friday after the full moon. People drive for miles to visit this doctor; who is a man. His reputation is so great that crowds gather in the early morning on Friday and wait patiently for their turn. One man waited for his turn from 4.30 in the morning until 5.30 in the evening. Other powwowers request their patients to face to the west while they are being treated.

Many people in this vicinity say they do not believe in powwowing, but will state some cure they have witnessed, and declare that, while they do not understand it, there must be something in it. Others ridicule the whole practice, and express nothing but contempt for those who indulge in it. The regular physicians describe it as a faith cure and say that under peculiar conditions there may be something in it. The powwowers have a large number of followers and believers among well educated

and intelligent people from all religious bodies. Any one, by investigation, may discover facts and incidents that will throw more light on the subject than this article is able to do.

F. A. COLEMAN, '92.

THE FISHER MAID.

Early in the morning,
  While the grass is wet,
Comes a little maiden
  With her fisher's net.

In she plunges boldly
  Where the breakers beat,
Like two white shells sparkling
  Shine her small white feet.

Lightly on the water
  Lies the silken snare,
Wove with knotted tresses
  Of her sunny hair.

Right and left she casts it,
  Never once in vain,
Fills her little basket,
  Then begins again.

Learn they nothing, think you,
  In the fishes' schools?
Thick, and ever thicker,
  Swim the little fools.

Silver mackerel, bearded
  Lobsters green as grass,
Red-finned perch, and bluefish,
  Striped and speckled bass.

Each one proudly thinking,
  "*I* her heart shall move,
My soft eyes must win her,
  I shall have her love."

But the little maiden
  Opens wide her door,
Draws them gasping, floundering,
  Sparkling, to the shore.

Then with heaving bosom
  Brighter shine her eyes.
Sweetly peals her laughter
  As she counts the prize.

Cruel little maiden!
  Cruel, though so small,
If you lived on fishes,
  You could not eat them all.

Foolish fish! though foolish,
  Yet your lot is sweet.
Gasping, floundering, sparkling,
  Dying at her feet. E. W.

EDITORIALS.

WE announce the election of Messrs. Sharpe, Heard, Evans, Symington, Banks, and Chamberlin to the QUARTERLY Board.

WITH this number of the QUARTERLY, its control passes into the hands of the new board. We only hope they may receive the support, both in spirit and in the material way, that the old board received.

BY this time the *Epitome* has been so well and carefully commented on, that any words on our part will sound like echoes from the past. But we congratulate them heartily on the monument they have erected to their painstaking labors. It is a credit to the college, both in matter and form.

THE Engineering Society has promise of a long and useful existence. The QUARTERLY, following the suggestion of the *Burr*, will in the future devote more space and attention to that which should play a most important part in the technical side of our college working life. We earnestly beg the members to prepare their papers with care and to endeavor to prepare them on subjects with which they are practically familiar. It is our intention to publish the best of the papers so prepared, so that they may become permanent.

ONCE more will a graduating class pass from the realms of old Lehigh to be diluted and mixed with the great world outside. It is the duty of the graduate, a debt he owes his *alma mater*, that his interest in her affairs does not die: that he does all in his power to aid and uphold her in her grand work. Let the graduates, if only two or three in one place, form an alumni organization, and if they can do more than tell of a few old college scrapes, they are on the right road at least.

WAIFS AND STRAYS.

WHAT a community of interests college men have, that are unknown to, or at least unparticipated in by, the rest of the work-a-day world. The name itself is a synonym that stands for much to the interested—synonymous with work and anxiety, pleasure and happiness; of freedom of mind and body to a considerable degree. What word, then, is so well calculated to express a thousand and one things in one?

There is a certain magic in the name that will annihilate time, and space, and distinction, and classes, when we use it ourselves or hear it used in other places and at other times than these. It will bring us back again, by mental paths, to scenes and experiences we shall be glad to think we were associated with, and this at times when these have all passed and gone. Perhaps it will remind us of things we will wish were changed, but, on the whole, it will bring us more pleasure than regret. Some of our fondest hopes and remembrances will be connected with our college days, and many a first cause of a series of events or actions in later life will find its origin and starting point in these four years.

A college life, with its little world within itself, its great plans and close friendships, its generous impulses, its trust and reliance in others, all are as the waters of the fabled fountain of Ponce de Leon, and seem to give perpetual youth to those who reach it; a youthfulness that will often be our stay in the misfortunes that may come to some of us, and will ever bring us back to a common level, when all honors and dignities are reduced to the common plane of youthful equality; when famous C.E.'s, A.C.'s, M.E.'s, and E.M.'s, E.E.'s, the light from whose inventions is dazzling the world, and metallurgists, whose discoveries have rendered useless the search for the universal solvent, judges and ministers, envoys extraordinary, and gentlemen who are plenipotentiary in more humble positions, all lay aside their titles and forget their signs of gray hairs and, perhaps, a care-worn face, to appear again on commencements and at class reunions as the plain Bobs and Jacks, J. E.'s and A.B.'s, C.M.'s and G.P.'s of a less discriminating time; when men who have undershot their mark, or have not made an altogether correct analysis of the problem of life, are greeted as though they had made a yearly bull's-eye, or had come within the required one fifth of one per cent.; when rivalries are forgot and small men feel themselves great, and great men see no especial value in their greatness; and the world's work is taken up again with lighter heart and a sense of a better and truer appreciation.

Yes, true college spirit offers and almost guarantees this to a man, and it is worth trying for. Be in touch with the college while you are there, and keep as much in touch with it as possible, after you leave, and you will be the younger for it. All too soon will our undergraduate days be over for Senior and Freshman alike, though a few years may intervene, but if the earning of his diploma makes the Senior "a happy rascal," surely the undergraduates remain "lucky dogs." If, in numbers, the latter do not equal the former, or in time do not all change their luck to happiness, remember that now and then one of us is the unwilling cause of a "dull thud;" and then too, a good many of us are "called home to accept lucrative positions." But if we return among our old associates, a word or a greeting is all that is necessary to place us on quite the old footing again; and so it will ever be. Heaven be praised for this cheering community of feeling.

ORIGINAL, AND GOOD.

A SENIOR is such a delightful creature when seen from his point of view. True, for three or four days in June the vain world shouts his name abroad, the papers tell of him, and then, alas, the poor Senior thinks his fame and fortune forever are made. But ere the stick from the last skyrocket can touch the earth he is forgotten. His glory, which but a few days before was brilliant, almost dazzling, is more like a poor little candle that has been out in some rain storm, clean gone out, extinguished. With envious eyes our alumnus of one year's standing holds himself aloof and with swelling breast and frowning brow beholds the fickle populace run after what was in his day a plain Junior. How easily, then, he would fight if some tormenting spirit should derisively shout at him, as one great wit did on an occasion: "If you please, sir, are you anybody in particular?" As each year marked by the advent of some new class of learned beings breaking forth into the light of day rolls by, the soreness wears away, and soon as a gray bearded alumnus he can smile at the vanities displayed by his younger college alumni brethren. He will smile indulgently at their high-flown sentiments so elaborately expressed for the benefit of the listening crowd of inconstant admirers. But what of that? We enjoy it all. As Solomon has said, "Vanity of vanities, all is vanity." The world is filled with it. But no matter how cynical our tongues may be, how smiling our faces, it shows we know and feel that deep beneath all that may seem as but a hollow show, there runs a vein of true love and honor on the part of college men for their college mother.

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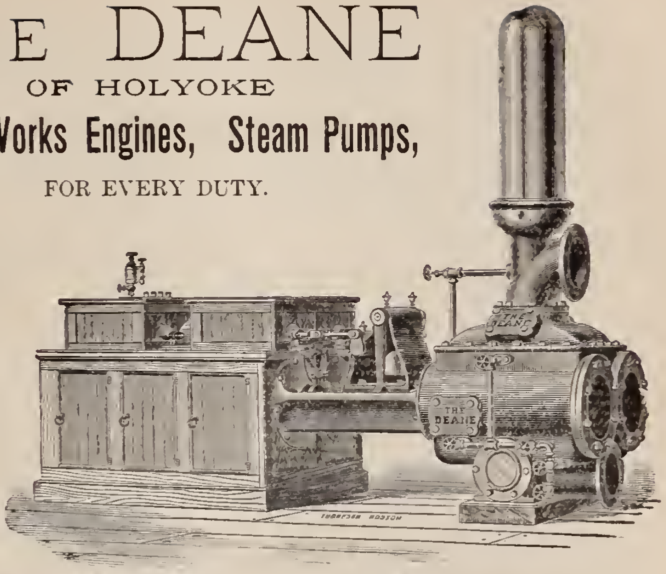

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